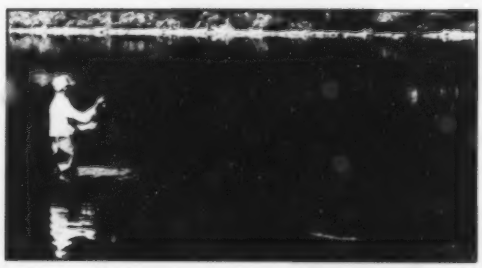
New Nouveau
Brunswick

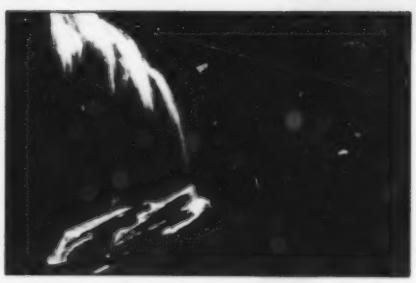
Environment

Environmental Planning
and Sciences Branch

Environnement

Direction de la planification et
des Sciences de l'environnement





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WATER QUALITY OF YOHO LAKE, 1975-1991

Technical Report T-9103

Environmental Planning and Sciences Branch

New Brunswick Department of the Environment

December 1991

Yoho Lake

Summary Sheet

Location: Kingsclear Parish, York County
45°46' Lat. 66°52' Long.

Watershed: Oromocto River, Saint John River

Dates Sampled: May 12, June 11, July 10, Aug. 18, Oct. 7, 1975
July 15, 1976
May 10, July 3, July 31, 1979
July 17, Aug. 22, 1984
Aug. 6, 1985
Aug. 10, 1986
Aug. 17, 1987
June 30, 1988
Sept. 4, 1989
July 26, 1990
June 20, July 25, Aug. 26, 1991

Physical Characteristics:

Lake Type: natural
Length: 2.98 km (1.85 miles)
Maximum Width: 0.61 km (0.38 miles)
Elevation: 47.3 m (155 ft.) above sea level
Maximum Depth: 11.3 m (37 ft.)
Mean Depth: 3.66 m (12 ft.)
Surface Area: 131 ha (324 acres)
Watershed Area: 9.73 km^2 (25.20 sq. miles)
Volume: 4,794,600 m^3 (169,189,697 $ft.^3$)
Flushing Rate: 1.9 times/yr.
Stratified in Summer: yes [maximum temperature difference, surface to bottom, 6°C (11°F)]
Maximum Summer Temperature:
Surface: 24°C (75°F)
Depth: 18°C (64°F) at 7 m (23 ft.)

Water Quality:

soft, slightly acidic, moderately susceptible to acidification, well oxygenated, low nutrient content resulting in low biological production, free of major algal blooms; overall, suitable for support of aquatic life including cold water species of fish; fecal coliform bacteria concentrations acceptable for body contact recreation; no significant changes in water quality noted for the 1975-1991 period.

92-07746/

Lac Yoho

Sommaire

Lieu : Paroisse de Kingsclear, comté de York
45° 46' latit., 66° 52' longit.

Bassin hydrographique : Rivière Oromocto, fleuve Saint-Jean

Date du prélèvement des échantillons :
Le 12 mai, le 11 juin, le 10 juillet, le 18 août
le 7 octobre 1975
Le 15 juillet 1976
Le 10 mai, le 3 juillet, le 31 juillet 1979
Le 17 juillet, le 22 août 1984
Le 6 août 1985
Le 10 août 1986
Le 17 août 1987
Le 30 juin 1988
Le 4 septembre 1989
Le 26 juillet 1990
Le 20 juin, le 25 juillet, le 26 août 1991

Caractéristiques physiques :

Type de lac : naturel
Longueur : 2,98 km (1,85 mille)
Largeur maximale : 0,61 km (0,38 mille)
Élévation : 47,3 m (155 pi) au-dessus du niveau de la mer
Profondeur maximale : 11,3 m (37 pi)
Profondeur moyenne : 3,66 m (12 pi)
Aire de surface : 131 ha (324 acres)
Région du bassin hydrographique : 9,73 km^2
(25,20 milles carrés)
Volume : 4 794 600 m^3 (169 189 697 pi^3)
Taux d'évacuation : 1,9 fois par année
Stratifié en été : oui, [différence maximale de
température, de la surface au fond,
6 °C (11 °F)]
Température maximale d'été :
Surface : 24 °C (75°F)
Profondeur : 18 °C (64°F) à 7 m (23pi)

Qualité de l'eau :

douce, légèrement acide, modérément susceptible à l'acidification, bien oxygénée, faible teneur en substances nutritives entraînant une faible production biologique, libre d'importantes proliférations d'algues; en général, convenable au soutien de la vie aquatique y compris les espèces de poissons nordiques; concentrations de bactéries coliformes fécales acceptables pour les sports de contact corporel; aucun changement important par rapport à la qualité de l'eau noté pour la période de 1975 à 1991.

TABLE OF CONTENTS

Summary Sheet	i
Sommaire	ii
Introduction	1
Background	1
Water Quality Surveys	1
Findings	4
Conclusions and Recommendations	6
Literature Cited	26
Appendix I	Phosphorus Modelling, Yoho Lake

LIST OF FIGURES

Figure 1	Watershed of Yoho Lake	2
Figure 2	Sampling locations Yoho Lake 1975-1991	3
Figure 3	Yoho Lake summer dissolved oxygen (mg/l) and temperature (°C) profiles, July 15, 1976	22
Figure 4	Yoho Lake summer dissolved oxygen (mg/l) and temperature (°C) profiles, July 31, 1979	23
Figure 5	Yoho Lake summer dissolved oxygen (mg/l) and temperature (°C) profiles, June 30, 1988	24
Figure 6	Yoho Lake summer dissolved oxygen (mg/l) and temperature (°C) profiles, July 25, 1991	25

LIST OF TABLES

Table 1	Water quality parameters measured in Yoho Lake and guideline levels	7
Table 2	Water quality data, Yoho Lake, 1975-1991	11
Table 3	Water quality data, Yoho Lake, 1975-1991	13
Table 4	Water quality data, Yoho Lake, 1975-1991	15
Table 5	Fecal coliform bacteria densities (no./100ml), Yoho Lake, 1984-1991	17
Table 6	Medians of selected parameters, Yoho Lake, 1975-1991	20
Table 7	Trophic levels of lakes (after Dillon and Rigler 1975)	21

INTRODUCTION

The New Brunswick Department of the Environment conducts water quality surveys of rivers and lakes throughout the Province. Physical, biological, and chemical information is collected in order to catalogue and assess existing conditions and to determine long term trends in water quality.

This report presents results of the surveys conducted on Yoho Lake between 1975 and 1991, and provides an interpretation of the results.

BACKGROUND

Yoho Lake is situated in York County, approximately 30 km southwest of Fredericton. Its surface area is about 131 hectares and the land area of the watershed is about 842 hectares. The mean depth is 3.66 meters with a maximum of 11.3 meters, and the flushing rate is 1.9 times per year.

The lake drains to Yoho Stream (Figure 1) which flows to the Saint John River via the North Oromocto and Oromocto Rivers.

Significant cottage development began in the 1950's and has continued to the present with the shoreline almost completely utilized. While originally for seasonal use, many cottages have been upgraded for year round use and several permanent homes have been erected. Increased highway access and road improvements have aided development and plans exist for development beyond the shoreline strip.

The lake supports moderate fishing pressure for both native and stocked salmonids. Smallmouth bass have also been introduced. The main activity on the lake however, appears to be recreational boating and swimming.

WATER QUALITY SURVEYS

Water quality surveys (physical, chemical and biological measurements) were conducted on Yoho Lake in 1975, 1976, 1979 and 1984-1991. Only bacteria were measured in 1985-1987 and 1989.

Water samples were collected at four stations on the lake (Figure 2) which were located to indicate long-term background water quality. Surface water was sampled for bacteria, while both the surface and deeper waters were sampled for the remainder of the parameters listed in Table 1. Water samples for bacteria analyses were taken at the surface at near shore locations (Figure 2) to detect any local effects of shoreline development.

Figure 1

Watershed of Yoho Lake

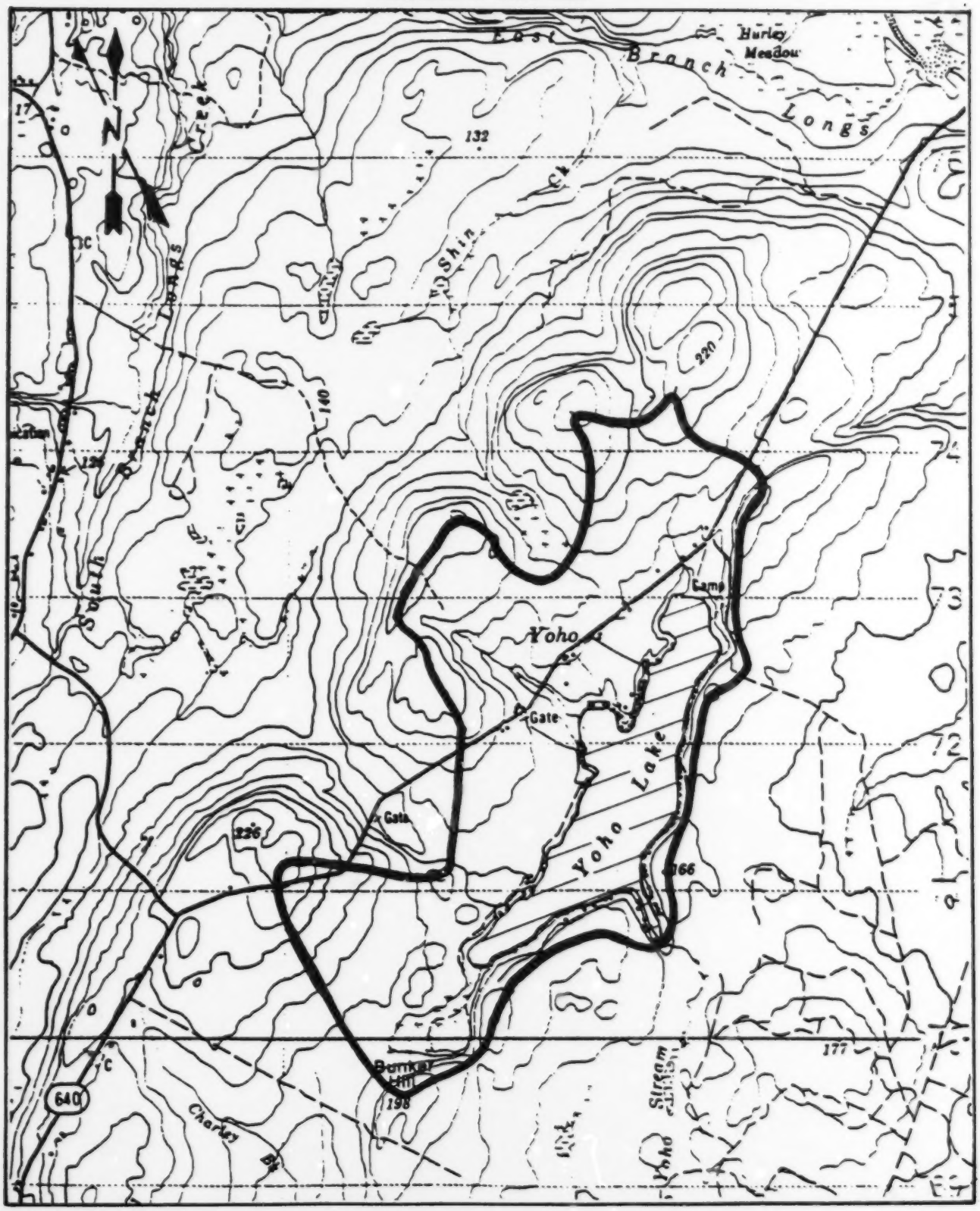
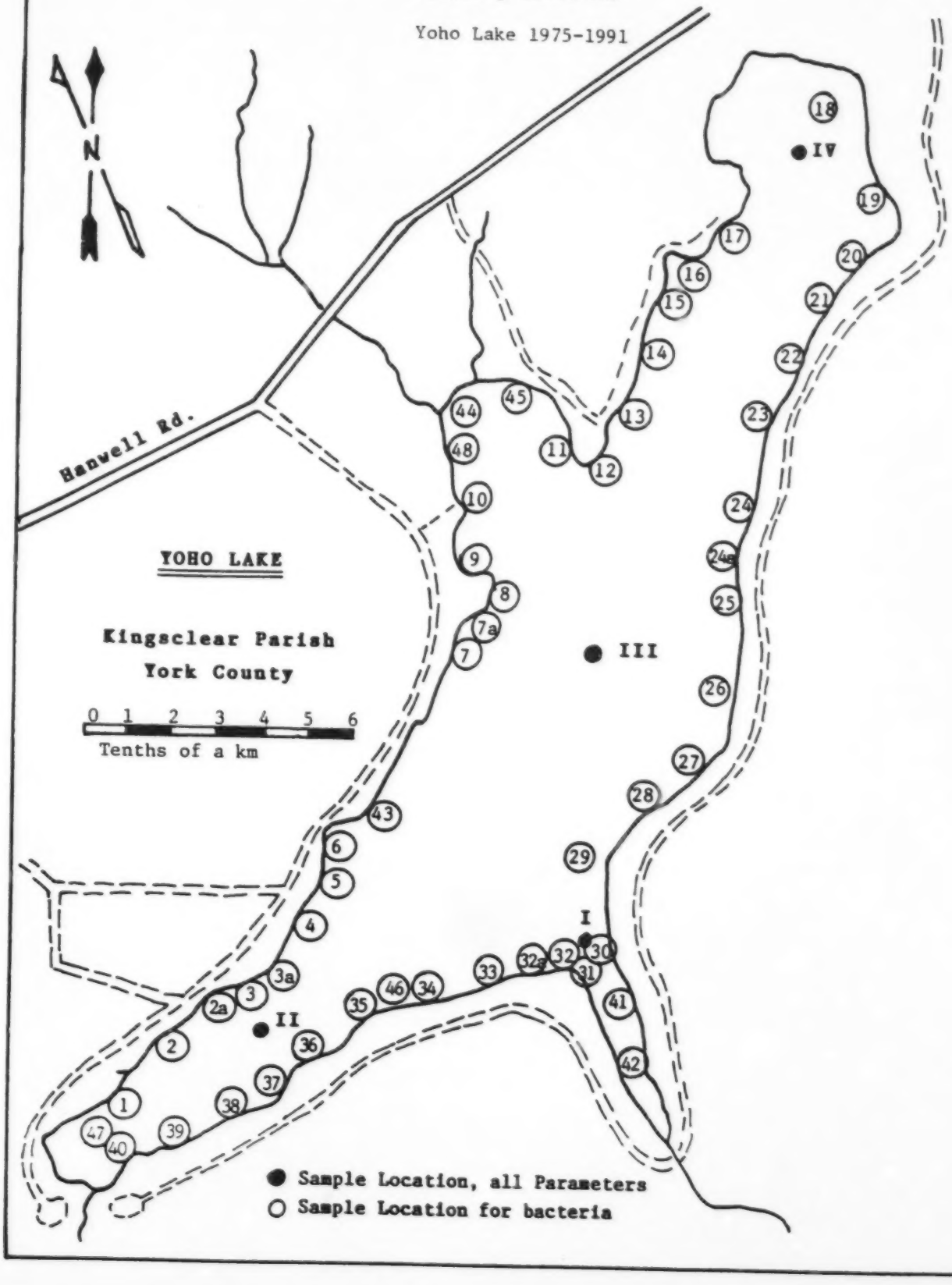


Figure 2

Sampling Locations

Yoho Lake 1975-1991



Dissolved oxygen, temperature, and Secchi depth (see Table 1 for explanation) were measured in the field. Fecal coliform bacteria analyses were completed at the Regional Laboratory, Dr. Everett Chalmers Hospital, Fredericton. The remaining parameters were analyzed at the N.B. Department of the Environment Laboratory in Fredericton.

FINDINGS

The water quality guidelines in Table 1 are based primarily on the Canadian Water Quality Guidelines (Canadian Council of Resource and Environment Ministers 1987) and Water Quality Sourcebook (McNeely, Neimanis and Dwyer 1979). They represent levels which will protect aquatic life from all effects, both lethal and sub-lethal.

With the exception of copper and lead, all parameters measured in each year (Tables 2-5, Figures 3-6) were within guideline values. Copper exceeded the guideline of 0.002 mg/l in 1988, 1990 and 1991 (Table 3). The high copper values in 1988 were found to be due to contamination of sample bottles. While maximum values in 1990 and 1991 exceeded the guideline, median* values were well below the guideline. Furthermore, maxima were well below the 0.02 mg/l concentration considered to be acutely toxic to fish (International Technical Advisory Subcommittee on Water Quality on the Saint John River 1980). Similarly, maximum values of lead exceeded the 0.001 mg/l guideline in 1984 and 1991, but medians were acceptable (Table 4). Maximum values were again below the acutely toxic limit of 0.03 mg/l (ibid. 1980).

There appear to be no major trends in the concentrations of the various parameters between 1975 and 1991. Total dissolved solids, conductivity, chloride, sodium and potassium exhibited what appear to be slight increases (Table 6). If real, these could have been caused by winter road salting, annual variations in the lake's flushing rate, or a combination of both. They would not be considered to be significant at this point in time, but may bear watching in the future.

Alkalinity and pH which are affected by acid rain, showed few changes with no indication of a downward trend.

Total phosphorus appears to have declined somewhat in 1990 and 1991, but the change may have been due to improved laboratory procedures which reduced the tendency for phosphorus measurements to be biased high.

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* The median value is the middle measurement in a data set arranged in ascending or descending order; that is, there are as many values higher than the median as there are lower.

The increased chlorophyll a concentrations in 1988 and 1990 could be considered to indicate greater algal production, but other data do not substantiate this. Normally, increased phosphorus inputs to a lake encourage algal growth which reduces sunlight penetration and hence, Secchi disk readings. Because Secchi depths and phosphorus showed no significant changes in 1988 and 1989, the chlorophyll a concentrations are considered to be anomalies.

Dissolved oxygen in the summer remained around 9 mg/l at the surface well above the 5.0 mg/l guideline. Oxygen measurements were consistent to about the 6 meter depth at which they declined in the final one to two meters to lows of 5.4 mg/l in 1976, 6.0 mg/l in 1979, 5.0 mg/l in 1988 and 6.2 mg/l in 1991 (Figures 3-6). Temperature followed a similar pattern declining between 0.5°C and 4.5°C in the final one to two meters of depth. A lake exhibiting this type of dissolved oxygen-temperature profile is considered to be weakly stratified.

Fecal coliform bacteria densities (Table 5) were well within recreational guidelines except for a high reading at Station 26 on July 23, 1990. Since previous and subsequent readings were low, it is assumed that the high number resulted from field or laboratory error. Stations 35 and 36 appear to have experienced a slight increase in fecal coliforms in August 1991. However, no trend is indicated at this time.

Dillon and Rigler (1975) developed a system for classifying lakes according to trophic status (Table 7). Yoho Lake would be in Level 1 as median chlorophyll a, except for the anomalies mentioned previously, has not exceeded 2 mg/m^3; dissolved oxygen has usually exceeded 5 mg/l; and the Secchi depth, although probably somewhat reduced by the water colour, approached 5 m.

Past studies have indicated that the phosphorus concentration measured in the spring of the year is related to summer chlorophyll a concentrations, and phosphorus at 0.01 mg/l corresponds to a chlorophyll a of 2 mg/m^3 (Dillon and Rigler 1975). Thus, for Yoho Lake to remain at Trophic Level 1, spring phosphorus should be below 0.01 mg/l. Although no sampling was carried out in the spring of the year, phosphorus measurements at other times indicated the levels in Yoho Lake were below 0.01 mg/l.

Dillon and Rigler (1975) developed a phosphorus model for lakes in which annual loads of phosphorus from all sources can be estimated and then used to predict the spring phosphorus concentration and hence, chlorophyll a. By setting a maximum phosphorus of 0.01 mg/l and estimating present natural inputs, the amount of phosphorus which may be artificially added to the lake without changing its trophic level can be calculated. Using the approximate phosphorus discharge from a cottage, and assuming all of the discharge reaches the lake, the maximum number of cottages that could be developed without harm to the lake can then be calculated. This has been done for Yoho Lake and indicates a cottage capacity of about 220 (see Appendix I for detailed information). Discharge for a year round home is considered to be about five times greater than that for a cottage. In the absence of cottages, the capacity of the lake for year round homes is therefore about 45.

CONCLUSIONS AND RECOMMENDATIONS

1. Water quality surveys conducted on Yoho Lake between 1975 and 1991 indicate that the lake was of good quality. The water was very soft, slightly acidic and moderately susceptible to acidification. The lake was well oxygenated and weakly stratified (little change from surface to bottom) for dissolved oxygen and temperature. It was suitable for the support of aquatic life, including cold water species of fish, but overall biological productivity was low. Fecal coliform bacteria levels in the lake were acceptable for body contact recreation.

2. For the most part, the various parameters measured were within the water quality guidelines established for the lake.

3. There appeared to be no major trends in the concentrations of the parameters measured.

4. The shoreline development capacity of the lake is about 220 cottages or 45 year round homes.

5. Because of expected development pressures in the future, monitoring of Yoho Lake should continue. Surveys conducted every 5 years, more often if problems appear to be developing, should be sufficient to determine long term trends. Bacteria sampling at inshore locations should continue to be included in such surveys.

Table 1 Water quality parameters measured in Yoho Lake and guideline levels			
Parameter	Description	Guideline*	Comment
pH (pH)	index of the hydrogen in concentration, 7 indicates neutral, less than 7 acidic, greater than 7 alkaline	6.5 - 9.0	
Total Alkalinity (Alkt)	ability of water to neutralize an acid		2-10 mg/l indicates moderate sensitivity to acidification
Conductivity (Cond)	indication of dissolved matter		normal range 10-50 microseimens/cm
Turbidity (Turb)	measure of suspended particles in water	for recreational use should not increase by more than 5.0 NTU (nephelometric turbidity units)	
Colour (Clra)	colour imparted to water by natural minerals or vegetation	100 units for recreational use	
Chloride (Cl)	major inorganic ion, in high concentrations is partial cause of salty taste in water		
Sulfate (SO_4)	oxidized form of sulfur	no limit established for aquatic life, less than 150 mg/l for drinking water	
Calcium (Ca)	an alkaline-earth metal, along with megnessium is primarily responsible for the hardness of water		less than 15 mg/l is common in New Brunswick surface waters
Magnesium (Mg)	an alkaline-earth metal, one of the two main components of hardness	less than 50 mg/l recommended for drinking water	

Table 1 (continued)			
Parameter	Description	Guideline*	Comment
Hardness (Hard)	principally the sum of calcium and magnesium		0-30 mg/l considered to be very soft, 31-60 mg/l soft, 61-120 mg/l moderately soft, 121-180 mg/l hard, above 180 mg/l very hard
Sodium (Na)	major inorganic ion, in high concentrations and in combination with chloride can cause salty taste in water	20 mg/l in drinking water of individuals on sodium restricted diets	
Potassium (K)	alkali metal, essential for plant and animal nutrition		seldom 20 mg/l in natural surface waters, generally less than 10 mg/l
Nitrate & nitrite (NOx)	combined forms of nitrogen, major nutrient for aquatic vegetation	less than 10 mg/l in drinking water	greater than 5 mg/l may reflect unsanitary conditions
Disolved organic carbon (DOC)	nutrient required for biological processes, decomposition of carbon compounds removes oxygen from water		greater than 15 mg/l may reflect unsanitary conditions
Total Kjeldahl nitrogen (TKN)	measure of both ammonia and organic nitrogen		0.1 to 0.5 mg/l is normal environmental range
Total Ammonia (NH_3T)	reduced inorganic form of nitrogen	varies with temperature and pH; at pH of 6.75 and temperature of 15°C guideline is 2.2 mg/l	
Total phosphours (TP)	essential plant nutrient, may stimulate algal growth		index of maximum concentrations is: 0.10 mg/l in flowing water, 0.05 mg/l for water flowing into lakes and reservoirs and 0.025 mg/l in lakes and reservoirs

Table 1 (continued)			
Parameter	Description	Guideline*	Comment
Iron (Fe)	fourth most abundant element in earth's crust	should not exceed 0.3 mg/l	
Manganese (Mn)	often found in association with iron		tolerance values for freshwater aquatic life are reported to range from 1.5 to 1000 mg/l
Copper (Cu)	essential for plant and animal nutrition in small amounts	0.002 mg/l in waters with a hardness of 0-60 mg/l	
Lead (Pb)	ubiquitous in the natural environment	should not exceed 0.001 mg/l in waters with a hardness of 0-60 mg/l	
Zinc (Zn)	essential element for plants and animals, relatively non-toxic to man but toxic to aquatic organisms	should not exceed 0.03 mg/l	
Cadmium (Cd)	usually present in water in trace quantities, highly toxic to man and aquatic life	0.0002 mg/l in waters with a hardness of 0-60 mg/l	
Aluminum (Al)	third most abundant element in the earth's crust	should not exceed 0.005 mg/l in waters with a pH of 6.5 or less; should not exceed 0.1 mg/l in waters with a pH of greater than 6.5	importance of pH to toxicity investigated only recently and significant gaps in knowledge remain
Suspended solids (SS)	a measure of material suspended in the water column	should not exceed 10 mg/l	
Total dissolved solids (TDS)	an index of the amount of dissolved substances in water	should not exceed 250 mg/l	

Table 1 (continued)			
Parameter	Description	Guideline*	Comment
Chlorophyll a (CHLA)	green pigment found in plants, can be used to estimate plant biomass		concentrations in unproductive, nutrient-poor waters range up to 4 mg/m^3, highly productive waters contain 10 to 100 mg/m^3
Phaeophytin (PHEO)	breakdown product of chlorophyll a		being a breakdowm product, it is used to make a correction in biomass estimates
Secchi disk (Secchi)	measure of water transparency, maximum depth at which a black and white 25 cm (10 inch) diameter disk can be seen in water		decrease in Secchi depth may indicate increased suspended matter such as that caused by an algal bloom
Dissolved oxygen (DO)	necessary for respiration in aerobic organisms	should be no less than 5.0 mg/l for protection of fish	
Fecal coliform bacteria	a group of bacteria found in the intestines of humans and warm blooded animals and present in their feces	geometric mean of at least 5 samples taken over a 30 day period should be less than 200 fecal coliforms per 100 ml	

* Unless indicated otherwise, guideline is the level established for the protection of aquatic life

Table 2 Water quality data, Yoho Lake, 1975-1991											
		pH	Alkt (mg/l)	Cond (us/cm)	Turb (NTU)	Clra	Cl (mg/l)	SO_4 (mg/l)	Ca-D (mg/l)	Mg-D (mg/l)	Hard (mg/l)
Guideline		**6.5-9.0**	**-**	**-**	**5.0 ***	**100**	**-**	**50**	**-**	**50**	**-**
1975	**MAX**	7.0	5.89	30.2	-	20	-	-	-	-	9.2
	MIN	6.1	0.71	21.9	-	0	-	-	-	-	5.0
	MED	6.6	2.34	23.9	-	5	-	-	-	-	7.2
	OBS	40	40	40	0	40	0	0	0	0	40
1976	**MAX**	6.5	3.75	29.0	0.42	5	-	-	-	-	9.3
	MIN	6.3	2.14	24.0	0.35	0	-	-	-	-	7.8
	MED	6.5	3.05	25.0	0.40	0	-	-	-	-	8.0
	OBS	8	8	8	8	8	0	0	0	0	8
1979	**MAX**	6.8	6.0	27.0	-	10	-	6.0	2.7	0.52	8.6
	MIN	6.4	3.3	19.0	-	0	-	3.4	1.6	0.45	5.9
	MED	6.6	4.3	21.0	-	5	-	3.8	2.0	0.48	7.0
	OBS	24	24	24	0	24	0	16	24	24	24
1984	**MAX**	6.82	4.9	23.5	0.72	5	1.44	3.30	2.6	0.540	8.3
	MIN	6.77	4.7	21.2	0.33	0	1.33	3.17	1.4	0.429	5.4
	MED	6.78	4.9	22.3	0.36	0	1.42	3.26	1.6	0.461	6.1
	OBS	6	6	6	6	6	6	6	6	6	6
1985	**MAX**	-	-	-	-	-	-	-	-	-	-
	MIN	-	-	-	-	-	-	-	-	-	-
	MED	-	-	-	-	-	-	-	-	-	-
	OBS	0	0	0	0	0	0	0	0	0	0
1986	**MAX**	-	-	-	-	-	-	-	-	-	-
	MIN	-	-	-	-	-	-	-	-	-	-
	MED	-	-	-	-	-	-	-	-	-	-
	OBS	0	0	0	0	0	0	0	0	0	0

Table 2 (continued)

		pH	Alkt (mg/l)	Cond (us/cm)	Turb (NTU)	Clra	Cl (mg/l)	SO_4 (mg/l)	Ca-D (mg/l)	Mg-D (mg/l)	Hard (mg/l)
Guideline		**6.5-9.0**	**-**	**-**	**5.0 ***	**100**	**-**	**50**	**-**	**50**	**-**
1987	**MAX**	-	-	-	-	-	-	-	-	-	-
	MIN	-	-	-	-	-	-	-	-	-	-
	MED	-	-	-	-	-	-	-	-	-	-
	OBS	0	0	0	0	0	0	0	0	0	0
1988	**MAX**	6.82	5.30	28.0	0.7	10	3.23	3.35	10.6	1.680	33.4
	MIN	6.79	5.04	27.5	0.1	5	3.06	3.18	2.1	0.657	7.9
	MED	6.81	5.13	27.8	0.5	5	3.22	3.31	2.3	0.668	8.6
	OBS	6	6	6	6	6	3	3	6	6	6
1989	**MAX**	-	-	-	-	-	-	-	-	-	-
	MIN	-	-	-	-	-	-	-	-	-	-
	MED	-	-	-	-	-	-	-	-	-	-
	OBS	0	0	0	0	0	0	0	0	0	0
1990	**MAX**	6.7	14.36	31.4	0.6	10	3.73	3.16	2.34	0.524	7.8
	MIN	6.52	7.00	31.0	0.4	10	3.51	3.08	2.17	0.428	7.3
	MED	6.63	7.62	31.0	0.4	10	3.54	3.11	2.25	0.442	7.6
	OBS	6	6	6	6	3	3	3	5	5	5
1991	**MAX**	6.7	20.0	33	0.7	10	4.0	3.4	2.8	0.611	9.1
	MIN	6.5	3.9	32	0.4	0	3.6	3.0	1.4	0.490	7.6
	MED	6.6	4.1	33	0.5	3	3.7	3.3	2.4	0.536	9.0
	OBS	15	15	15	15	15	15	15	15	15	9

* increase above background should not exceed 5.0 NTU

D = dissolved

MAX = maximum; MIN = minimum; MED = median; OBS = number of observations (number of times measured)

Table 3 Water quality data, Yoho Lake, 1975-1991

		Na (mg/l)	K (mg/l)	NO_x (mg/l)	DOC (mg/l)	TKN (mg/l)	NH_3T (mg/l)	TP (mg/l)	Fe-x (mg/l)	Mn-x (mg/l)	Cu-x (mg/l)
Guideline		**20**	**-**	**L10*1**	**-**	**-**	**2.2*2**	**-**	**0.3**	**-**	**0.002**
1975	**MAX**	-	-	0.033	5	1.58	-	0.05	-	-	-
	MIN	-	-	L0.01	L1	L0.10	-	L0.01	-	-	-
	MED	-	-	L0.01	3	0.27	-	0.01	-	-	-
	OBS	0	0	40	40	40	0	39	0	0	0
1976	**MAX**	-	-	0.026	7.5	0.7	-	0.08	-	-	-
	MIN	-	-	0.010	L1.0	0.4	-	0.01	-	-	-
	MED	-	-	0.014	2.5	0.7	-	0.02	-	-	-
	OBS	0	0	8	8	8	0	8	0	0	0
1979	**MAX**	-	-	0.01	7.1	0.3	-	0.06	-	-	-
	MIN	-	-	L0.01	L1.0	L0.1	-	L0.01	-	-	-
	MED	-	-	L0.01	1.0	0.2	-	0.01	-	-	-
	OBS	0	0	24	24	24	0	24	0	0	0
1984	**MAX**	1.04	0.341	0.02	3.16	0.19	-	0.01	0.065	L0.01	L0.01
	MIN	0.98	0.305	L0.01	2.85	0.13	-	L0.01	L0.05	L0.01	L0.01
	MED	1.01	0.319	L0.01	2.96	0.17	-	0.01	L0.05	L0.01	L0.01
	OBS	6	6	6	6	6	0	6	6	6	6
1985	**MAX**	-	-	-	-	-	-	-	-	-	-
	MIN	-	-	-	-	-	-	-	-	-	-
	MED	-	-	-	-	-	-	-	-	-	-
	OBS	0	0	0	0	0	0	0	0	0	0
1986	**MAX**	-	-	-	-	-	-	-	-	-	-
	MIN	-	-	-	-	-	-	-	-	-	-
	MED	-	-	-	-	-	-	-	-	-	-
	OBS	0	0	0	0	0	0	0	0	0	0

Table 3 (continued)

		Na (mg/l)	K (mg/l)	NO_x (mg/l)	DOC (mg/l)	TKN (mg/l)	NH_3T (mg/l)	TP (mg/l)	Fe-x (mg/l)	Mn-x (mg/l)	Cu-x (mg/l)
Guideline		**20**	**-**	**L10*1**	**-**	**-**	**2.2*2**	**-**	**0.3**	**-**	**0.002**
1987	**MAX**	-	-	-	-	-	-	-	-	-	-
	MIN	-	-	-	-	-	-	-	-	-	-
	MED	-	-	-	-	-	-	-	-	-	-
	OBS	0	0	0	0	0	0	0	0	0	0
1988	**MAX**	3.10	0.341	0.010	3.56	0.27	0.014	0.014	T0.191	0.035	0.030
	MIN	1.85	0.318	T0.003	3.18	0.15	0.014	0.012	T0.183	0.029	0.024
	MED	1.95	0.323	T0.007	3.47	0.18	0.014	0.012	T0.187	0.030	0.026
	OBS	6	6	6	6	6	1	5	3	3	3
1989	**MAX**	-	-	-	-	-	-	-	-	-	-
	MIN	-	-	-	-	-	-	-	-	-	-
	MED	-	-	-	-	-	-	-	-	-	-
	OBS	0	0	0	0	0	0	0	0	0	0
1990	**MAX**	2.32	0.38	T0.01	4.50	0.217	0.10	0.007	T0.005	0.024	0.003
	MIN	2.25	0.375	T0.01	4.29	T0.073	0.08	T0.003	T0.003	0.013	T0.0001
	MED	2.27	0.378	T0.01	4.40	0.333	0.09	0.004	T0.007	0.014	0.0016
	OBS	5	5	6	6	6	6	6	3	3	3
1991	**MAX**	2.6	0.39	0.004	3.0	0.39	0.65	0.004	0.057	0.107	0.008
	MIN	2.3	0.37	0.001	1.2	0.09	0.01	0.0	0.0	0.0	0
	MED	2.4	0.38	0.002	2.3	0.20	0.05	0.0	0.01	0.03	0.001
	OBS	15	15	15	15	15	15	15	9	9	9

*1 increase above background should be less than 10 mg/l

*2 at water temperature of 15°C and pH of 6.5

x = acid extractable concentration

L = less than

T = trace levels, in range of the detection levels of the laboratory methods used

MAX = maximum; MIN = minimum; MED = median; OBS = number of observations (number of times measured)

Table 4 Water quality data, Yoho Lake, 1975-1991

		Pb-x (mg/l)	Zn-x (mg/l)	Cd-x (mg/l)	Al-x (mg/l)	SS (mg/l)	TDS (mg/l)	CHLA (mg/m³)	PHEO (mg/m³)	Secchi (m)	Fecal coliforms (no./100ml)
Guideline		**0.001**	**0.03**	**0.0002**	**0.1 ***	**10**	**250**	-	-	-	**200**
1975	**MAX**	-	-	-	-	-	-	1.5	1.4	-	1
	MIN	-	-	-	-	-	-	0.1	0.5	-	0
	MED	-	-	-	-	-	-	0.55	1.0	-	0
	OBS	0	0	0	0	0	0	30	30	0	16
1976	**MAX**	-	-	-	-	-	-	1.3	1.3	-	2
	MIN	-	-	-	-	-	-	0.4	0.4	-	0
	MED	-	-	-	-	-	-	0.6	0.5	-	0
	OBS	0	0	0	0	0	0	8	8	0	4
1979	**MAX**	-	-	-	-	-	-	2.3	2.2	5.0	2
	MIN	-	-	-	-	-	-	0.4	0.3	3.5	0
	MED	-	-	-	-	-	-	0.9	1.1	4.0	0
	OBS	0	0	0	0	0	0	16	16	11	20
1984	**MAX**	0.009	L0.01	L0.01	0.028	-	19.5	-	-	5.0	-
	MIN	L0.002	L0.01	L0.01	0.012	-	11.5	-	-	3.5	-
	MED	L0.002	L0.01	L0.01	0.015	-	14.0	-	-	4.0	-
	OBS	6	6	6	5	0	6	0	0	6	0
1985	**MAX**	-	-	-	-	-	-	-	-	-	-
	MIN	-	-	-	-	-	-	-	-	-	-
	MED	-	-	-	-	-	-	-	-	-	-
	OBS	0	0	0	0	0	0	0	0	0	0
1986	**MAX**	-	-	-	-	-	-	-	-	-	-
	MIN	-	-	-	-	-	-	-	-	-	-
	MED	-	-	-	-	-	-	-	-	-	-
	OBS	0	0	0	0	0	0	0	0	0	0
1987	**MAX**	-	-	-	-	-	-	-	-	-	-
	MIN	-	-	-	-	-	-	-	-	-	-
	MED	-	-	-	-	-	-	-	-	-	-
	OBS	0	0	0	0	0	0	0	0	0	0

Table 4 (continued)

		Pb-x (mg/l)	Zn-x (mg/l)	Cd-x (mg/l)	Al-x (mg/l)	SS (mg/l)	TDS (mg/l)	CHLA (mg/m³)	PHEO (mg/m³)	Secchi (m)	Fecal Coliforms (no./100ml)
Guideline		**0.001**	**0.03**	**0.0002**	**0.1 ***	**10**	**250**	-	-	-	**200**
1988	**MAX**	T0.001	0.017	-	0.017	T1.2	28.0	3.09	0.522	4.0	-
	MIN	T0.0008	0.011	-	0.016	T1.2	27.0	1.13	L0.1	4.0	-
	MED	T0.0009	0.014	-	0.016	T1.2	27.5	2.27	0.065	4.0	-
	OBS	3	3	0	3	3	3	5	5	4	0
1989	**MAX**	-	-	-	-	-	-	-	-	-	-
	MIN	-	-	-	-	-	-	-	-	-	-
	MED	-	-	-	-	-	-	-	-	-	-
	OBS	0	0	0	0	0	0	0	0	0	0
1990	**MAX**	T0.0	T0.0001	-	0.030	T0.6	22.5	8.277	T0.0	5.0	-
	MIN	T0.0	T0.0	-	0.014	T0.2	15.5	2.881	T0.0	5.0	-
	MED	T0.0	T0.0001	-	0.018	T0.4	21.0	5.264	T0.0	5.0	-
	OBS	3	2	0	3	3	3	6	6	3	0
1991	**MAX**	0.002	0.009	-	0.024	9.0	30.0	-	-	5.0	-
	MIN	T0.0002	0.002	-	0.015	0.0	18.0	-	-	4.0	-
	MED	T0.0005	0.002	-	0.019	T1.2	26.5	-	-	5.0	-
	OBS	9	9	0	9	9	9	0	0	15	0

* for waters with a pH greater than 6.5

L = less than
T = trace level, in range of detection level of the laboratory method used
MAX = maximum; MIN = minimum; MED = median; OBS = number of observations (number of times measured)

Table 5 Fecal coliform bacteria densities (no./100 ml), Yoho Lake, 1984-1991

Stn. No.	July 17 1984	Aug. 22 1984	Aug. 6 1985	Aug. 10 1986	Aug. 17 1987	June 30 1988	Sept. 4 1989	July 23 1990	June 20 1991	July 25 1991	Aug. 26 1991
1	4	1	1	-	-	-	6	0	0	3	4
2	-	-	1	10	15	1	4	1	0	1	10
2a	-	-	0	-	-	2	2	-	-	-	-
3	-	-	0	15	4	1	5	1	0	1	6
3a	1	1	0	15	15	-	7	-	-	-	-
4	-	-	-	10	14	1	7	2	0	0	6
5	-	-	-	7	10	0	3	7	0	1	6
6	-	-	-	-	-	1	6	1	0	1	5
7	-	-	-	-	-	0	4	2	0	2	1
7a	-	-	-	4	10	-	4	-	-	-	-
8	-	-	-	-	-	1	3	1	0	1	2
9	-	-	-	14	8	-	4	7	0	3	5
10	7	2	0	20	3	-	2	7	0	0	2
11	-	-	-	5	11	2	6	1	0	1	4
12	4	3	0	6	2	-	3	1	0	1	0
13	-	-	-	7	6	0	3	0	0	1	3
14	5	1	0	12	15	-	2	6	1	4	3
15	-	-	-	10	5	0	2	9	0	4	5

Table 5 (continued)

Stn. No.	July 17 1984	Aug. 22 1984	Aug. 6 1985	Aug. 10 1986	Aug. 17 1987	June 30 1988	Sept. 4 1989	July 23 1990	June 20 1991	July 25 1991	Aug. 26 1991
16	-	2	0	10	6	-	-	8	0	3	7
17	-	-	-	-	-	-	-	8	0	3	3
18	3	2	3	20	10	0	3	3	0	1	3
19	3	0	0	15	5	-	-	2	1	0	1
20	-	-	-	-	-	-	-	1	0	1	1
21	5	2	0	10	10	0	1	5	0	3	1
22	4	1	1	13	6	-	-	10	0	1	3
23	-	-	-	-	-	0	4	10	1	0	2
24	5	1	1	12	13	-	4	0	0	1	5
24a	-	-	-	-	-	-	1	-	-	-	-
25	2	4	0	7	7	0	1	2	0	1	2
26	-	-	-	-	-	-	1	410	0	5	2
27	-	-	-	9	6	0	-	1	0	8	1
28	2	2	0	-	-	-	3	2	0	1	2
29	-	-	-	6	2	1	2	1	0	0	3
30	2	8	0	14	1	-	1	1	1	2	2
31	-	-	-	-	-	-	-	4	1	0	1
32	-	-	-	2	2	0	1	1	1	-	-

Table 5 (continued)

Stn. No.	July 17 1984	Aug. 22 1984	Aug. 6 1985	Aug. 10 1986	Aug. 17 1987	June 30 1988	Sept. 4 1989	July 23 1990	June 20 1991	July 25 1991	Aug. 26 1991
32a	-	-	-	-	-	-	1	-	-	1	2
33	-	-	-	-	-	-	3	8	2	2	8
34	1	1	0	3	5	-	1	1	3	4	12
35	-	-	-	-	-	1	2	8	1	2	35
36	-	-	-	1	5	-	2	0	1	4	44
37	-	-	-	-	-	-	1	0	0	2	4
38	1	2	0	3	13	1	2	4	1	11	5
39	-	-	-	-	-	-	2	6	1	4	13
40	-	-	-	-	-	-	4	0	0	2	3
41	-	-	-	-	-	-	-	-	0	0	3
42	-	-	-	-	-	-	-	-	0	3	5
43	-	-	-	-	-	-	-	-	0	4	5
44	-	-	-	7	10	-	-	-	1	0	1
45	-	-	-	18	25	-	-	-	2	4	2
46	-	-	-	-	-	-	-	-	0	0	19
47	-	-	-	-	-	-	-	-	0	2	5
48	-	-	-	6	10	-	-	-	-	-	2

Table 6 Medians of selected parameters, Yoho Lake, 1975-1991										
Year	TDS (mg/l)	Cond (us/cm)	Cl (mg/l)	Na (mg/l)	K (mg/l)	Alkt (mg/l)	pH	TP (mg/l)	Chla (mg/m^3)	Secchi disk (m)
1975	-	23.9 (40)	-	-	-	2.34 (40)	6.6 (40)	0.01 (39)	0.55 (30)	-
1976	-	25.0 (8)	-	-	-	3.05 (8)	6.5 (8)	0.02 (8)	0.6 (8)	-
1979	-	21.0 (24)	-	-	-	4.3 (24)	6.6 (24)	0.01 (24)	0.9 (16)	4.0 (11)
1984	14.0 (6)	22.3 (6)	1.42 (6)	1.01 (6)	0.319 (6)	4.9 (6)	6.78 (6)	0.01 (16)	-	4.0 (6)
1985	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-
1988	27.5 (3)	27.8 (6)	3.22 (3)	1.95 (6)	1.95 (6)	5.13 (6)	6.81 (6)	0.012 (5)	2.27 (5)	4.0 (4)
1989	-	-	-	-	-	-	-	-	-	-
1990	21.0 (3)	31.0 (6)	3.54 (3)	2.27 (5)	2.27 (5)	7.62 (6)	6.63 (6)	0.004 (6)	5.264 (6)	5.0 (3)
1991	26.5 (9)	33 (15)	3.7 (15)	2.4 (15)	0.38 (15)	4.1 (15)	6.6 (15)	0.0 (15)	-	5.0 (15)

( ) NUMBER OF OBSERVATIONS

Table 7 Trophic levels of lakes
(after Dillon and Rigler 1975)

Level 1: median summer chlorophyll a concentration of 2 mg/m^3; for lakes to be used primarily for body contact recreation and where it is desirable to maintain dissolved oxygen concentration in the deeper waters above 5 mg/l to preserve cold water fisheries. The lake will be extremely clear with a mean Secchi disk visibility of 5m (may be lower in brown water lakes) and will be very unproductive.

Level 2: median summer chlorophyll a concentration up to 5 mg/m^3; for lakes to be used for recreation but where the preservation of cold water fisheries is not imperative. The lake will be moderately productive and correspondingly less clear, with a mean Secchi disk visibility of 2-5m.

Level 3: median summer chlorophyll a concentration up to 10 mg/m^3; for lakes where body contact recreation is of little importance, but emphasis is placed on warm water fisheries (bass, pickerel, bluegill, yellow perch). Dissolved oxygen in the deeper waters will commonly be depleted. Secchi disk depths will be low (1 - 2 m).

Level 4: median summer chlorophyll a concentration up to 25 mg/m^3; lakes suitable only for warm water fisheries. Secchi disk depth less than 1.5m; oxygen in deeper waters is depleted early in the summer.

Figure 3

YOHO LAKE

SUMMER DISSOLVED OXYGEN (mg/l) AND TEMPERATURE (°C) PROFILES

July 15,1976

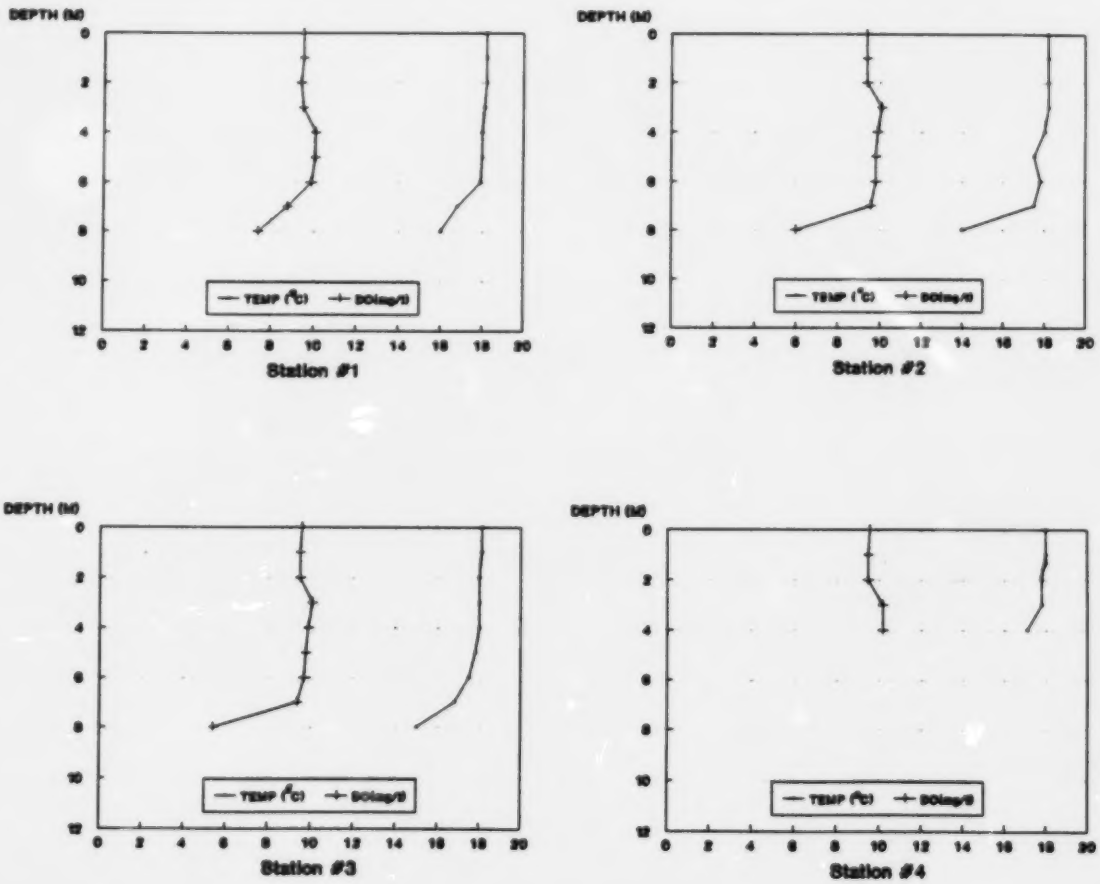


Figure 4

YOHO LAKE

SUMMER DISSOLVED OXYGEN (mg/l)
AND TEMPERATURE (°C) PROFILES

July 31, 1979

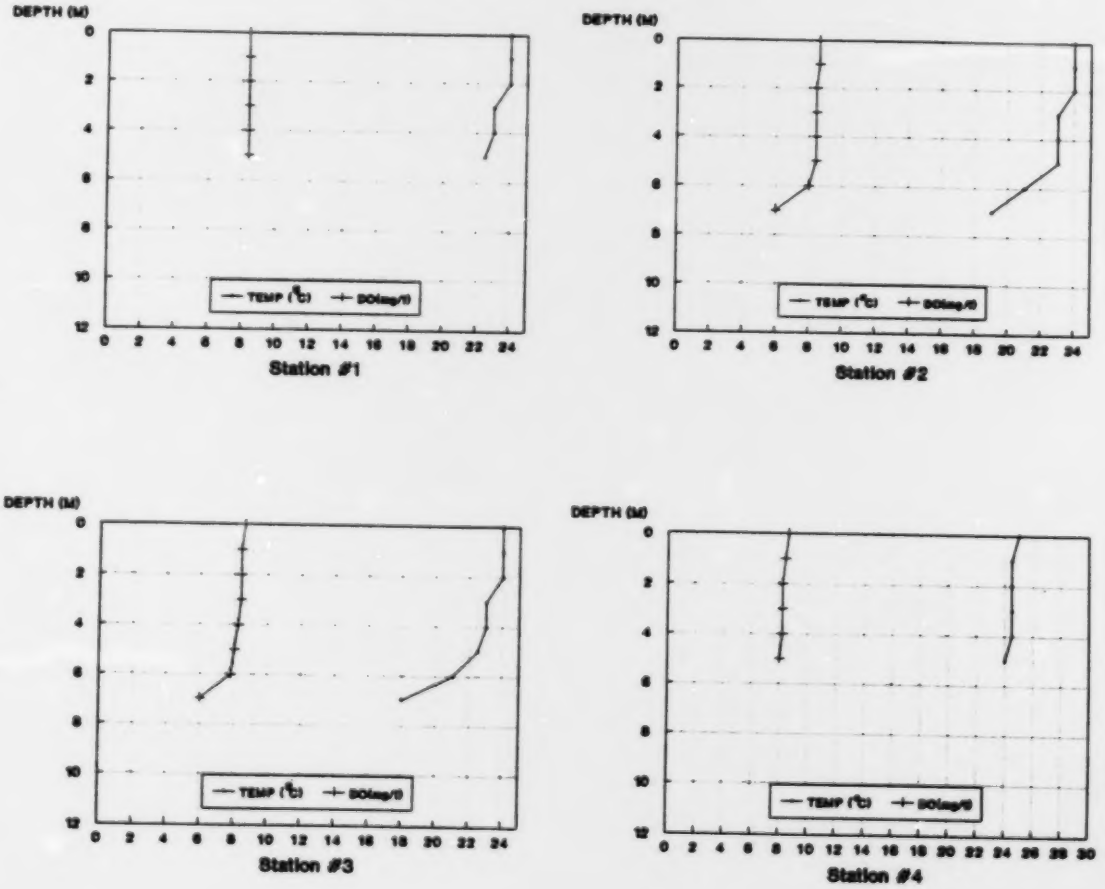


Figure 5

YOHO LAKE

SUMMER DISSOLVED OXYGEN (mg/l) AND TEMPERATURE (°C) PROFILES

June 30, 1988

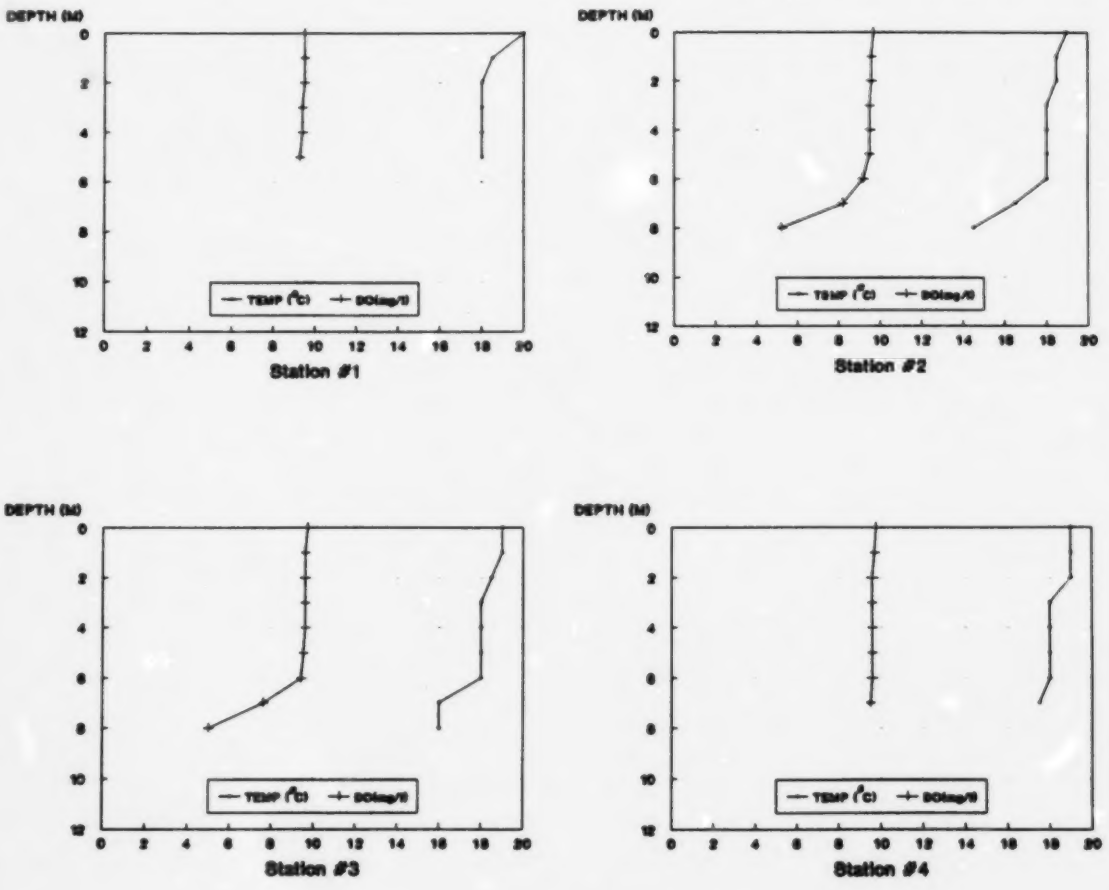
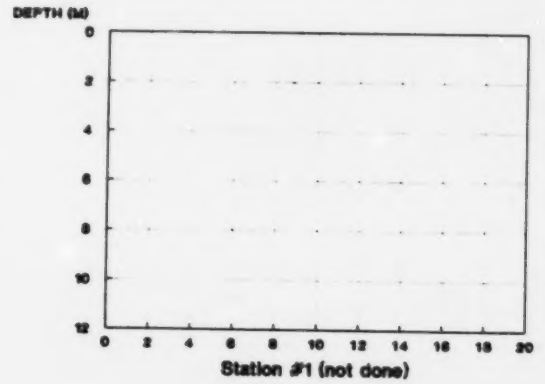


Figure 6

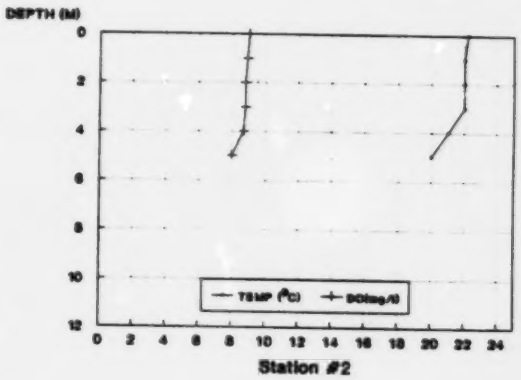
YOHO LAKE

SUMMER DISSOLVED OXYGEN (mg/l) AND TEMPERATURE (°C) PROFILES

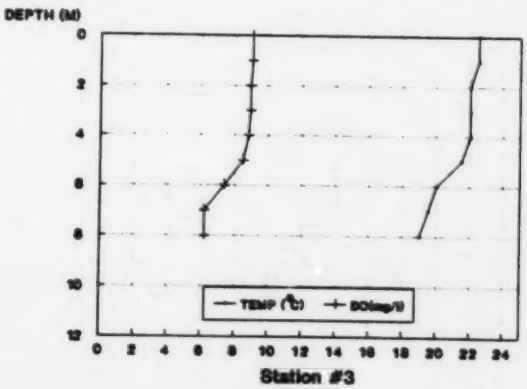
July 25, 1991



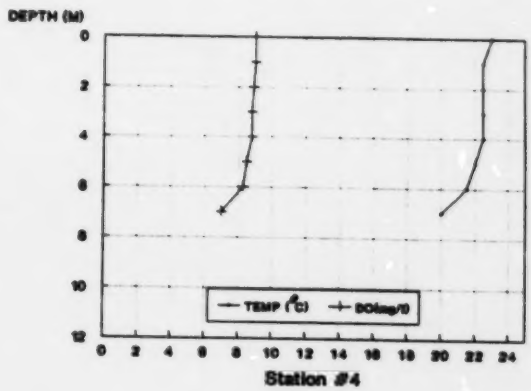
Station #1 (not done)



Station #2



Station #3



Station #4

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Appendix I

Phosphorus Modelling, Yoho Lake

PHOSMOD
YOHO LAKE

Natural P Land (P.L.)	
Watershed Area (m^2)	9370000.000
P Export (mg/m^2)	10.200
P Land (mg/yr)	85884000.000
Lake Surface Area (m^2)	1310000.000
Areal Loading ($mg/m^2/yr$) Land	65.560
Natural P Precipitation (P.P)	
Annual Precipitation (m/yr)	1.200
Lake Surface Area (m^2)	1310000.000
P Conc. (in NS mg/m^3)	12.000
Mg. P.P./yr	18864000.000
Areal Loading ($mg/m^2/yr$) Precip.	14.400
Spring P Concentration (mg/m^3)	
Drainage Area (m^2)	9730000.000
Runoff (m)	0.820
Lake Area (m^2)	1310000.000
Precipitation (m)	1.200
Evaporation (m)	0.380
Net Precipitation	0.820
Total Outflow Vol (cubic m/yr)	9052800.000
qs =	6.911
Retention Coefficient	0.603
Mean Depth (m)	3.660
Lake Volume (m^3)	4794600.000
Flushing Rate (p)	1.888
Spring p Concentration [P] (mg/m^3)	4.617

P per Cottage (kg/yr)	0.552
Max Permissible Total Areal Loading ($mg/m^2/yr$)	172.346
Areal Loading From Land & Areal Loading From Precipitation ($mg/m^2/yr$)	79.960
Max Permissible Areal Loading (New Cottages)	92.386
Total Permissible P Discharge New Cottages (kg/yr)	121.025
Total Permissible Number of New Cottages	219